1550

Erbium fibre laser pumped nanosecond optical parametric oscillator

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Abstract

We report a periodically-poled lithium niobate optical parametric oscillator pumped by a frequency doubled Q-switched erbium-fibre laser. Pump tuning of the OPO signal with thresholds below 10μJ was demonstrated. Signal tuning range was 0.99-1.45μm.

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There is much interest in fibre lasers as compact, inexpensive and tunable sources. Only recently have they achieved the high powers suitable for efficient nonlinear interactions[1]. We report the combination of a high power Q-switched fibre laser and highly nonlinear periodically poled lithium niobate (PPLN), resulting in the first fibre pumped singly-resonant optical parametric oscillator, (OPO).

A large mode area erbium Q-switched fibre laser was pumped by a 400mW 980nm diode source. The fibre laser produced 50ns pulses with up to 3kW peak power and 180μJ of energy at a repetition rate of 200Hz. A narrow bandpass filter selected the output wavelength from 1530 to 1560nm with a 0.25nm bandwidth.

A PPLN sample, which we fabricated by electric field poling, frequency doubled the fibre laser output. The 19mm long 18.7μm period grating was anti-reflection coated and gave a maximum external conversion efficiency of 60%. Using this PPLN crystal an output >70μJ from 772nm to 779nm could be generated, determined by the combined limitations of temperature tuning range, filter transmission and laser gain spectrum.

The second harmonic output was used to pump an OPO consisting of a 20mm long multiple grating PPLN sample (19, 19.5, 20 & 20.5μm) in a plano-concave cavity. The crystal was anti-reflection coated with MgF_2 to give <2.5% losses per face at 1300nm. The cavity mirrors were highly reflecting between 1000 and 1450nm, and highly transmitting from 720 to

850nm. The concave input mirror had a radius of curvature of 100mm. The output coupler had 25% signal transmission.

The pump was focused to a spot radius of 50μm close to the back plane mirror. The cavity length was optimised to 110mm, giving an OPO threshold of ~10μJ, figure 1. A quantum efficiency of 15% was achieved, with an average pump depletion of 44%.

The OPO was temperature tuned across all the gratings to generate signal wavelengths between 0.99 & 1.45μm, figure 2. This corresponds to 1.7 to 3.5μm idler wavelengths, the tuning range being limited only by the mirror reflectivities.

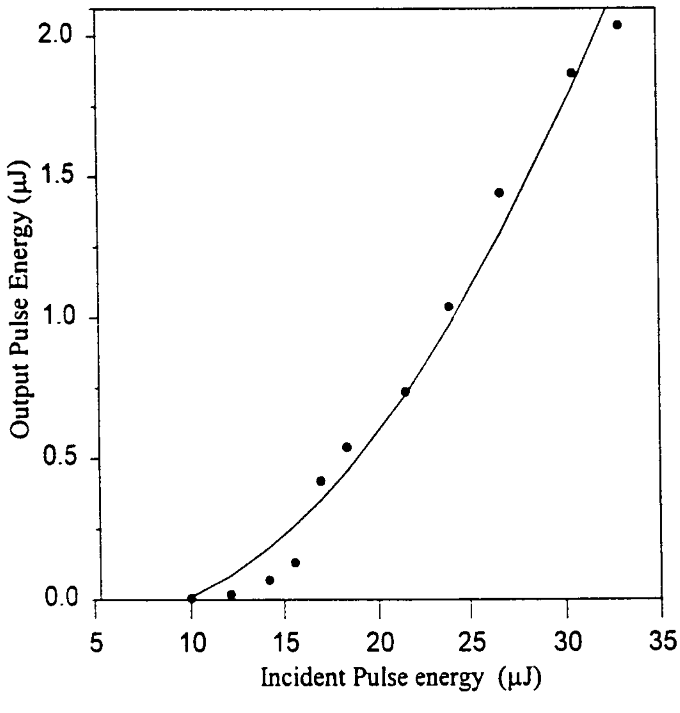
A significant feature in this experiment was the possibility of using wavelength tuning of the pump to tune the signal output wavelength. We used the 19μm grating to obtain 130nm signal tuning with only 7nm pump variation. If we fixed the grating period and temperature of both SHG and OPO crystals we obtained up to 9nm tuning with the 19mm crystal, and 15nm for a 10.5mm second harmonic generation crystal. The 15nm was achieved with 0.6nm of pump tuning at 779nm, corresponding to a tuning multiplier of 25.

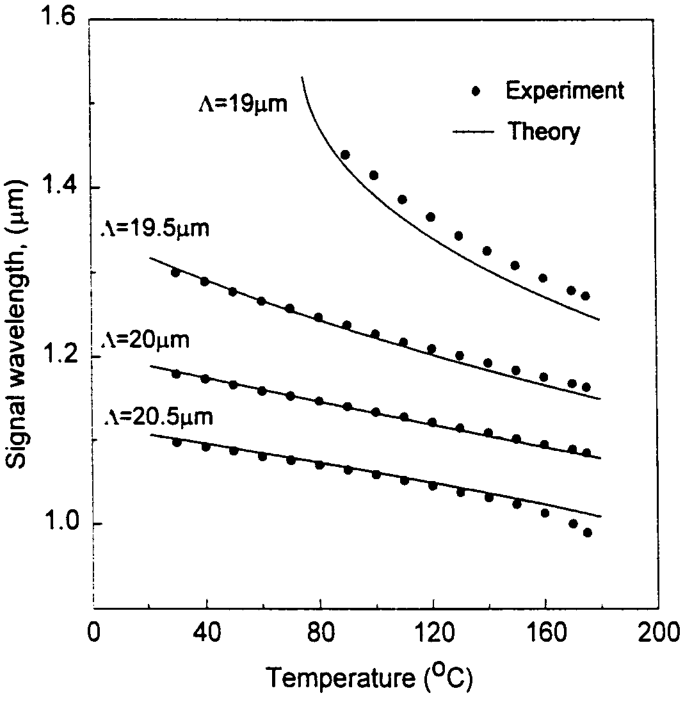
A further extension of the pump tuning could be obtained by directly pumping an OPO with the fibre laser output at 1550nm. The higher thresholds (~ 80μJ for a 20mm crystal) could be compensated by using longer PPLN crystals and better quality anti-reflection coatings. Also the inclusion of a tunable acousto-optic-filter within the laser cavity should allow rapid tuning of the OPO, making for a very versatile and useful source.

1 D.J. Richardson, J.D. Minelly, D.C. Hanna, 'Fibre Laser Shine Brightly' LF World, Vol. 33 No. 9, 87-96 Sept(1997)

Fig. 1 Output signal at 1150nm energy against incident pump pulse energy at 770nm, with a 25% output coupler.

Fig. 2 Signal wavelength variation with OPO temperature for the four different gratings, (19, 19.5, 20 and 20.5μm) for fixed input wavelength of 778.4nm.


Output Pulse Energy (μJ)
2.0
1.5
1.0
0.5
0.0
5
10
15
20
25
30
35
Incident Pulse energy (μJ)



Λ=19μm
Experiment
Theory
Λ=19.5μm
Λ=20μm
Λ=20.5μm
Signal wavelength, (μm)
Temperature (°C)
1.6
1.4
1.2
1.0
0
40
80
120
160
200